National Aeronautics and
Space Administration

STS–107: Space Research and You

Fighting Fire in Microgravity

Water Mist Fire Suppression Experiment (MIST)

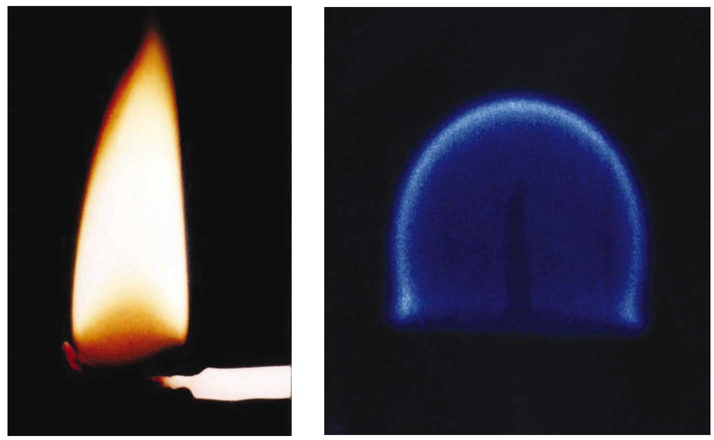
Everyone knows that water will put out a fire. Turn a hose on a backyard campfire, and the fire will go out and the ashes wash away in the runoff. It is simple enough to do, but what happens when the fire is in an office surrounded by computers, paintings, papers, and other objects that can be damaged by water from sprinklers?

For many years, the answer was to use halons, bromine-based compounds that attacked fire chemically, making it impossible for it to burn. Halons are extremely harmful to the ozone layer — more than ten times more harmful than Freon in air conditioners — and have been banned worldwide in compliance with the Montreal Protocol on Substances That Deplete The Ozone Layer. This makes water once again the prime tool for fighting a fire, since no other acceptable replacements have been found.

On Earth, water has a predictable effect on fire.

So, how do you fight fire with water in such a way that the fire goes out, while damage to property is reduced or eliminated?

The answer to that is the focus of some out-of-this-world industrial research being conducted on the STS–107 mission. Environmental Engineering Concepts, Inc., and Arizona Mist, Inc. have partnered with the Center for the Commercial Applications of Combustion in Space (CCACS), a NASA-sponsored Commercial Space Center (CSC), to investigate the use of fine water mists in fighting a fire.



In Earth gravity, convection causes a flame (left) to rise in the cone shape to which we are accustomed. In a microgravity environment, convection has no effect. As a result, the flame (right) of a candle becomes a dome shape.

It is common knowledge that water will put out fire. However, exactly how the water interacts with the flame is not as clearly understood. On Earth, a candle flame has its well-known tear-drop shape because of gravity. As the candle burns, the hot air created by the flame rises, giving the flame its length. As this happens, fresh air is pulled in at the base, providing oxygen needed to support the combustion and causing the base to swell. The air currents created by this process make it very hard to study both combustion and how to fight it.

In microgravity, which is the condition of apparent weightlessness experienced by astronauts in orbit and often called "zero gravity," these currents are reduced or eliminated. This allows scientists to study exactly what happens in the combustion process. It also allows them to study how water droplets, like those in a fine fog, interact with the flame and extinguish it.

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Project Scientists: J. Thomas McKinnon, Angel Abbud-Madrid, and Edward P. Riedel

Background Information

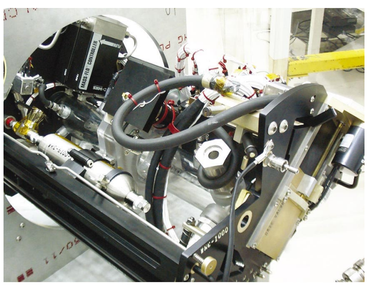
Science

The investigations on STS–107 by Arizona Mist, Environmental Engineering Concepts and CCACS will study how different sizes and concentrations of droplets will affect a thin layer of flame, known as a laminar flame.

In microgravity, water droplets form free floating spheres.

The flame will be produced by igniting a mixture of propane and air inside a transparent tube in the Combustion Module (CM–2), a forerunner facility for combustion research on the *International Space Station* (*ISS*). The CM–2 makes it possible for many different types of combustion research, both commercial and scientific, to be conducted safely on the Shuttle.

The investigations on STS–107 will create droplets of water between 20 to 40 microns in size, as opposed to droplets from conventional sprinklers that are larger than 1 millimeter in size, and study how they interact with the flame.



Water Mist Fire Suppression Experiment (Mist), developed by CCACS will be operated in the CM–2 Experiment Mounting Structure (EMS) aboard SPACEHAB on STS–107.

These data will be used on the ground to improve existing computer and mathematical models. With better data to use in these models, investigators can then run detailed simulations to test theories and obtain more accurate results. These can then be further refined on the ground and on the *ISS*. Water mist investigations on the *ISS* will be able to use different water injection systems, droplet sizes, and other fire scenarios to support this important research.

With halon replacements expected to become an increasingly large part of the $2 billion-a-year fire suppression industry, the research being done on STS–107 is of great commercial interest. Of more importance, however, it is work that will help keep us safe in the years to come.

This panel of images taken during a low-gravity test of the Mist experiment shows a flame after ignition in the left frame, encountering water mist in the middle frame, and slowing down and breaking up in the right frame.

Benefits

- Determine optimum water concentration and water droplet size to suppress fires.
- Improve models for designing the next generation of environmentally friendly and low-cost fire-fighting systems.

Early Results

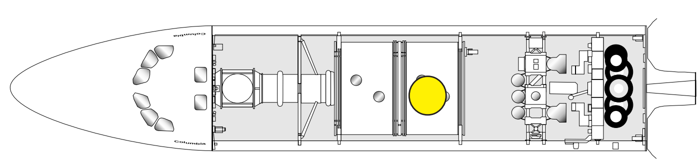
Mist investigators believe that fine water droplets are the key to fighting many fires quickly and efficiently. Preliminary investigations were conducted in 1997 using the drop tower facility at the Colorado School of Mines. This permitted the experiment hardware to be tested, and a quick check of data and theories to be performed. Using the knowledge from the drop tube tests, the investigation was refined and then flown on NASA's KC–135 weightless training aircraft. The data from the KC–135 flights allowed further refinement of the investigation so that the maximum benefit can be obtained from the work to be performed on the STS–107 mission.

During MSL–1 (STS–94) in 1997, Payload Commander Janice E. Voss used an earlier version of the Combustion Module (CM–1) to perform combustion experiments.

The microgravity research has also been augmented by an extensive ground-based research program. Research conducted at the Arvada Fire Training and Research Center in Arvada, Colorado on fires using ultra-fine misting heads developed by Environmental Engineering Concepts has shown that fine water mists can be extremely effective in fighting common fires. In fact, testing has shown that fires can be put out with significantly less water using mists than with conventional systems. Computer modeling by CCACS in support of the research indicates that smaller droplets are indeed more effective at extinguishing fires.

Applications

- Ships (machinery spaces)
- Aircraft (passenger cabin and cargo)
- Spacecraft
- Libraries, museums
- Telecommunication racks
- Commercial cooking areas.



Approximate location of this payload aboard STS–107.